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A BOOSTER LOW-LEVEL RF SYSTEM

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Introduction

A system to provide the radio frequency signal to the booster rf cavities is described in this engineering note. The system is compared to other possibilities.

General Description

The system measures the beam position and the beam phase relative to the cavity voltage. It controls the frequency and phase of the voltage applied to the cavity. This is really only one independent and one dependent variable. That is the cavity phase is the integral of the frequency and the beam position is the integral of the beam phase.

The possible contenders for the system design can be divided into two classes, those with an oscillator and those without. For this definition an oscillator is an electronic device that has analog voltages as inputs and a sine wave output whose frequency is higher than any frequency components in the analog inputs. It is clear that any synchrotron rf system is an oscillator when taken as a whole, but this classification has to do with an identifiable block within the system.

It has been shown[1] that the difference between these classes of systems is in the transient response. The systems with an oscillator have an additional pole at the origin in the S-plane. This is a minor difference in the basic systems and can be completely eliminated by adding either a differentiator or integrator depending which system you prefer. The comparison between systems or classes of systems therefore reduces to questions of hardware; simplicity, economics, experience, etc.

The system described in this note is shown in Fig. 1. It does not include an oscillator (with the exception of starting oscillator). The phase feedback loop produces the proper phase shift in phase shifter B to keep its input in phase with the cavity voltage. The purpose of this loop is to compensate for the time delays in the system and phase irregularities in the distribution system. For a time delay of 1 μsec the phase shift required is $\Delta f \times \tau = 22$ cycles. Since this phase shifter is within a loop, its tolerances are not tight. The variable time delay allows the loop to be adjusted to compensate for pure time delays between the pickup electrode and the phase detector.

Phase shifter A provides the control point for moving the beam radially or, equivalently, in phase. It should be noted that a step command to this phase shifter produces a step change in phase independent of the transient response of the phase loop. That is, the state of phase shifter B does not change in such an event.

The fundamental frequency will be extracted from its harmonics and side bands by limiting and filtering with fixed filters. Because the side bands due to coherent phase oscillations are less than 1 part in 10^4 away from the fundamental for more than one half the acceleration cycle, they cannot be easily removed by a tracking narrow band amplifier. Therefore, this nonlinear limiting technique is used.

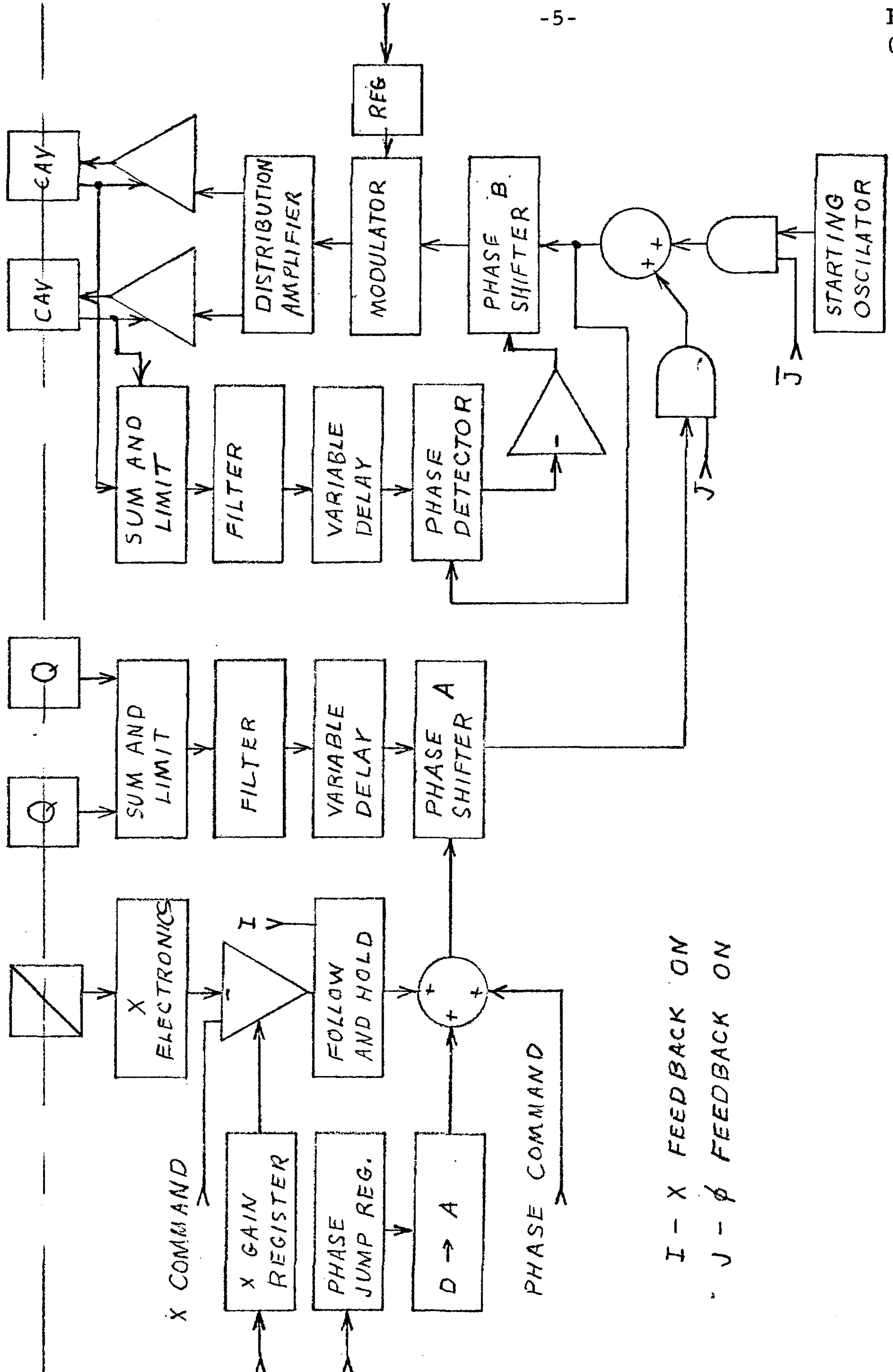
Comparison

In all systems considered, the fundamental component of an induction electrode signal must be detected. Even when an oscillator is employed the fundamental is required for phase detection. The advantage of this system over the oscillator system is the simplicity of phase damping loop. For instance, there are no phase detectors controlling this loop with their associated filters. The system $A\beta$ is simply -1 until the band pass characteristics of the amplifier cavity combination are included and this characteristic enters all systems similarly.

Digital versions were considered. It is difficult to use a general purpose machine because the data rates (typically 10 times the phase oscillation frequency or up to 700 kHz) press the state of the art. This then would require additional digital hardware to reduce these data rates. With the added equipment, the system becomes more complex than the analog counterpart.

REFERENCES

[1] E. C. Raka, Some Remarks on Beam Controlled Acceleration, Brookhaven National Laboratory Accelerator Department (AGS) Internal Report ECR-5, Aug. 18, 1961.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